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Research on the Selection of Industrial Organization Pattern in Western Regions under Low-carbon Economy Background

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Abstract

An enterprise benefit model is built up in this paper on the basis of economic and technical elements as well as ecological resource elements to study the enterprise benefit issue of two industrial production and organization patterns, the cluster production and circulatory production from the double perspectives of economic benefit and ecological benefit. The results suggest that the economic benefit of traditional cluster production is notably superior to that of circulatory production and the ecological benefit of circulatory production is in turn notably superior to that of the traditional cluster production. Based on the respective strong points of the abovementioned industrial production and organization patterns, a new industrial organization pattern, i.e. circulatory industrial cluster pattern enabling the uniform optimization of economic and ecological benefits is brought forth in this paper. Under the background of low-carbon economy, this pattern is the best approach to the construction of green growth pole in western regions.

Keywords: low-carbon economy; industrial organization pattern; industrial cluster; circulatory production; circulatory industrial cluster

1. Introduction

Industrial organization pattern is the sum of the specific formation pattern and operation pattern of industrial system based on the production organization, market organization and management organization of industry. It includes size distribution of an enterprise, coordination mechanism of relations among enterprises as well as connection mode and intensity. Industrial organization pattern is of great significance to the running performance of industry. Reasonable industrial organization pattern can promote the effective competitions and cooperation among enterprises in industrial organization and

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improve the productivity, innovation rate and competitive power of industry, while unreasonable industrial organization pattern will affect the development of industry. Industrial production and organization patterns under low-carbon economy background have become an extremely important and crucial factor influencing the benefits of industry (including economic benefit and ecological benefit). Cluster production and circulatory production are the two industrial production and organization patterns imposing the greatest impact on the development pattern of industrial economy in today's world, but each of them has its advantages and disadvantages and they can neither achieve the optimal combination of economic and ecological benefits separately and thus cannot sufficiently meet the sound and fast as well as sounder and faster industrial development demands under low-carbon economy background. To that end, the exploration of a new industrial organization pattern excellent both in economic benefit and ecological benefit is necessary in order to realize the rapid and sustainable economic development in western regions.

2. Main Characteristics and Limitations of the Two Industrial Production Organization Patterns

2.1. Main characteristics and limitations of cluster production organization pattern

Cluster production organization pattern is reflected in the manner of industrial cluster. Traditional industrial cluster refers to the agglomeration of enterprises, their subsidiaries and underlings manufacturing products of the same kind as well as the advantage of forming sustainable competitions. As an efficient, stable and fast industrial organization pattern, industrial cluster has comparatively higher production efficiency, economic benefit, greater innovation capacity and competitive edge and plays a very important role in driving the rapid growth of regional economy. On today's world economic map, all regions and industries with great competitive edge and sound development momentum have something to do with industrial cluster. American economist Michael Porter regards traditional industrial cluster as a spatial organization form with potential efficiency and benefits as well as competitive edge in terms of flexibility. He holds that the agglomeration effect of traditional industrial cluster will make labor division more specialized and intensive and specialized job market and sales market will play down the dealing cost of enterprises in the cluster, promote knowledge innovation and overflow of enterprises and enhance the competitive edge of enterprises so as to improve the productivity and economic benefits of enterprises and even the cluster as a whole. [1]

Although industrial cluster has its unique economic benefit advantages, a good many of problems are discovered in its development process, of which, the most noticeable and common ones are related to resources, environment and ecology. For the time being, many traditional industrial clusters in China are established on the basis of natural resource endowment and huge consumption of resources. The consequential problems such as resource scarcity, environmental pollution and ecological deterioration increasingly loom large and eventually become the barrier standing in the way of economic development in western regions. Hence, traditional industrial cluster pattern is not enough to solve problems of resources, ecology and environment and unable to undertake the important task of sustainable and harmonious development of economy in western regions.

2.2. Main characteristics and limitations of circulatory production organization pattern

Circulatory economy integrates the comprehensive utilization of resources, cleaner production, ecological design and sustainable consumption under the guidance of ecology laws and adopts ecological economy planning to plan social and economic activities and reconstruct industrial economic system to enable industrial symbiosis combination for resource sharing and by-products exchange among different enterprises to be developed, to take the wastes of the upstream as the raw materials of downstream and to

realize the comprehensive utilization of wastes to enable regional materials and energies to be sustainably utilized in economic cycle. It follows the principle of "reduction, recycling, recirculation, resource recovery and harmless treatment" and assemblies the characteristics of such circular flow as "resource utilization—green production—resource regeneration". Comparing with traditional production modes, circulatory economy features low consumption, low emission, high efficient and is environment-friendly. Great ecological benefits are created internationally and in a good many of regions in China and in the practical operation of industrial circulatory economy.

Although circulatory economy has improved resource utilization efficiency and showed great environmental and ecological benefits, there are still deficiencies in the pure circulatory economic pattern. The most serious deficiencies are the insignificant economic benefit resulted from excessively high running cost and unstable system resulted from single-chain cycle structure. During the course of circulatory economy promotion in different regions, the problem of excessive high extra operation cost resulted from emission reduction, consumption reduction and immature conversion technology arises; in addition, as the prevailing raw materials at present are extremely cheap and the cost for resource recovery and pollution control are extremely high, it is hard to produce economic benefit. Besides, the current circulatory economy mostly adopts the single-chain exchange pattern of by-products among enterprises and thus lacks of flexibility. Once a process in the industry breaks, the ecological chain of the entire industry may become unbalanced and unavailable. Rigid structure results in the weakness in competitive edge among enterprises and thus produces lower industry efficiency. Hence, pure circulatory economic pattern cannot achieve the goal of leap-frog economic development in western regions.

3. Analysis of Comprehensive Benefit of the Two Production Organization Patterns

3.1. Benefit model of industrial organization pattern

Comprehensive benefit analytical model of industrial organization pattern is set up and the following simplified hypotheses are made for the convenience of analysis and discussion:

(1) The comprehensive benefit of any industrial production, operation and organization pattern Y encompasses two parts, i.e. economic benefit of industry Y_J and ecological benefit of environment Y_S. That is:

$$Y = Y_J + Y_S \tag{3.1}$$

(2) The changes and increase of economic benefit Y_J (which can be measured by output to some extent) are subject to Cobb-Douglas production function [2]. That is:

$$Y_J(t) = C_J N^{\alpha} (RK)^{1-\alpha} = C_J \lambda e^{(1-\alpha)gt} \quad (0 < \alpha < 1) \tag{3.2}$$

Here, given that the total capital N of the entire industrial organization remains unchanged, that the element efficiency R reflects the regional productivity level and remains constant in certain period and that technical and economic element K is subject to the impact of such factors as human resource, scientific and technological progress and knowledge innovation and in the exponential growth. That is, $K = K_0 e^{gt}$. g is the growth rate, α is elasticity coefficient, λ is constant and C_J is the corresponding dimensional coefficient of benefit.

(3) The changes and increase of ecological benefit Y_S (which can be measured by compensatory yield of resource and environment to some extent) is subject to Logistic ecological function [3]. That is:

$$Y_S(t) = C_S \frac{M_S X_S^0 e^{r_S t}}{(M_S - X_S^0) + X_S^0 e^{r_S t}} \tag{3.3}$$

Where, M_S is the maximum capacity of resource and environment of ecological benefit of the corresponding organization pattern, X^0 is the initial value of its ecological benefit, r is the growth rate and C_S is the corresponding dimensional coefficient.

If A represents the industrial organization running under industrial cluster organization pattern and B represents industrial organization running under circulatory economic organization pattern, then the comprehensive benefits of the two types of industrial organization can be respectively expressed as follows:

$$Y_A(t) = Y_{AJ} + Y_{AS} = C_{AJ}\lambda_A e^{(1-\alpha_A)g_A t} + C_{AS}\frac{M_{AS}X_{AS}^0 e^{r_{AS}t}}{(M_{AS} - X_{AS}^0) + X_{AS}^0 e^{r_{AS}t}} \quad (3.4)$$

$$Y_B(t) = Y_{BJ} + Y_{BS} = C_{BJ}\lambda_B e^{(1-\alpha_B)g_B t} + C_{BS}\frac{M_{BS}X_{BS}^0 e^{r_{BS}t}}{(M_{BS} - X_{BS}^0) + X_{BS}^0 e^{r_{BS}t}} \quad (3.5)$$

The economic benefit and ecological benefit of industrial organization running under industrial cluster pattern and that under circulatory economic pattern will be compared and analyzed respectively and the comprehensive benefit of the two will be discussed on the basis of this model.

3.2. Comparison and analysis of economic benefits of enterprises under the two industrial organization patterns

The economic benefit of enterprises respectively running under the two organization patterns is analyzed. According to the foregoing hypothesis, the economic benefit function of industrial organization pattern running in the manner of industrial cluster can be concluded:

$$Y_{AJ}(t) = C_{AJ}\lambda_A e^{(1-a_A)g_A t} \qquad (0 < \alpha_A < 1) \quad (3.6)$$

In a similar way, the economic benefit function of industrial organization pattern running in the manner of circulatory economy can also be concluded:

$$Y_{BJ}(t) = C_{BJ}\lambda_B e^{(1-a_B)g_B t} \qquad (0 < \alpha_B < 1) \quad (3.7)$$

For easy comparison, given that the industrial scale of industrial cluster pattern and circulatory economic pattern is equivalent (it can be construed as the total capital of the two is equivalent in a sense). That is, they are both created in regions at the equal development level of productivity and the elasticity coefficient and dimension coefficient of the two are equivalent. Then:

$$R_A = R_B \;;\quad C_{AJ} = C_{BJ} \;;\quad \alpha_A = \alpha_B \quad (3.8)$$

As enterprises in industrial cluster have greater competitive edge than those in circulatory economy and industrial cluster has greater innovation advantages and industry efficiency than circulatory economy, the economic and technical elements in industrial cluster have greater growth rate than those in circulatory economy. That is:

$$g_A \geqslant g_B \quad (3.9)$$

The formula below can be concluded from formulae (3.8) and (3.9):

$$(1-\alpha_B)g_B \leqslant (1-\alpha_A)g_A \quad (3.10)$$

Now, the formula below can be concluded from formulae (3.6) and (3.7) and by reference to formula (3.8):

$$\lim_{t\to\infty}\frac{Y_{BJ}(t)}{Y_{AJ}(t)} = \lim_{t\to\infty}\frac{\lambda_B}{\lambda_A}e^{[(1-a_B)g_B-(1-a_A)g_A]t} = 0. \quad (3.11)$$

Thus, sufficiently small $\varepsilon_1 > 0,$ exists, which enables:

$$Y_{BJ}(t) < \varepsilon_1 Y_{AJ}(t) \qquad (t \to \infty) \tag{3.12}$$

That is, at $t \to \infty$, the formula below can be concluded:

$$Y_{BJ}(t) << Y_{AJ}(t) \tag{3.13}$$

The result suggests that when the condition of formula (3.10) is met and with the elapse of time, the industrial economic benefit created under industrial cluster organization pattern will be well above that under circulatory economy organization pattern. This is the major reason why industrial economy parks are generally wild about developing industrial cluster in the initial and medium periods of construction.

3.3. Comparison and analysis of ecological benefits of enterprises under the two industrial organization patterns

The ecological benefit function of industrial organization pattern running in the manner of industrial cluster can be concluded from formulae (3.3) and (3.4):

$$Y_{AS}(t) = C_{AS} \frac{M_{AS} X_{AS}^0 e^{r_{AS}t}}{(M_{AS} - X_{AS}^0) + X_{AS}^0 e^{r_{AS}t}} \tag{3.14}$$

Where, M_{AS} is the maximum capacity of ecological benefit of corresponding resource and environment under industrial cluster organization pattern, r_{AS} is the ecological benefit growth rate of industrial cluster organization pattern and X_{AS}^0 is the initial value of the corresponding ecological benefit. In a similar way, the ecological benefit function of industrial organization pattern running in the manner of circulatory economy can be concluded:

$$Y_{BS}(t) = C_{BS} \frac{M_{BS} X_{BS}^0 e^{r_{BS}t}}{(M_{BS} - X_{BS}^0) + X_{BS}^0 e^{r_{BS}t}} \tag{3.15}$$

Where, M_{BS} is the maximum capacity of ecological benefit of corresponding resource and environment under circulatory economy organization pattern, r_{BS} is the ecological benefit growth rate of circulatory economy organization pattern and X_{BS}^0 is the initial value of the corresponding ecological benefit.

For the convenience of comparison, suppose that industrial cluster production organization is located in the same region as the circulatory economy production organization and under the same resource and environmental conditions as well as equivalent dimensional coefficient of ecological benefit, while the ecological benefit capacity of resource and environment of industrial organization running under circulatory economy pattern is greater than that under industrial cluster pattern. That is:

$$C_{AS} = C_{BS} \quad ; \quad M_{AS} < M_{BS} \tag{3.16}$$

As multiple circulations of materials and energies are adopted for circulatory economy pattern and high-efficient utilization of resources can be achieved and the negative impact on ecological environment is less than common industrial cluster pattern, the ecological benefit growth rate of industrial organization running under circulatory economy pattern is greater than that under industrial cluster pattern. That is:

$$r_{AS} < r_{BS} \tag{3.17}$$

The deduction below can be made according to formulae (3.14) and (3.15) and by reference to formulae (3.16) and (3.17):

$$\lim_{t\to\infty} \frac{Y_{AS}(t)}{Y_{BS}(t)} = \lim_{t\to\infty} \frac{C_{AS} M_{AS} X_{AS}^0 [(M_{BS} - X_{BS}^0) e^{-r_{BS}t} + X_{BS}^0]}{C_{BS} M_{BS} X_{BS}^0 [(M_{AS} - X_{AS}^0) e^{-r_{AS}t} + X_{AS}^0]} e^{2(r_{AS} - r_{BS})t} = 0 \tag{3.18}$$

Thus, the sufficiently small $\varepsilon_2 > 0$, exists, which enables:

$$Y_{AS}(t) < \varepsilon_2 Y_{BS}(t) \quad (t \to \infty) \tag{3.19}$$

That is, at $t \to \infty$, the formula below can be concluded:

$$Y_{AS}(t) << Y_{BS}(t) \tag{3.20}$$

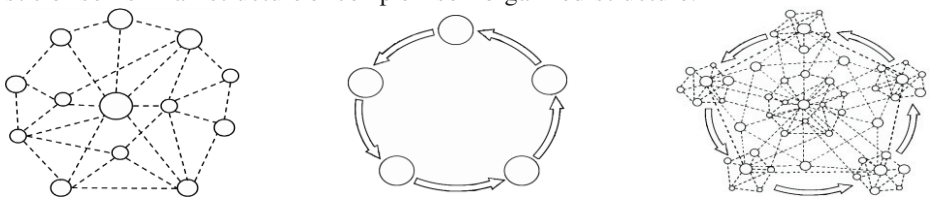
The result suggests that when the condition of formula (3.17) is met and with the elapse of time, the ecological benefit created by industrial organization under circulatory economy pattern will be well above that under industrial cluster organization pattern. This is the major reason why governments of many countries and regions, in consideration of the sustainable development of society, economy, resource and environment, hope all industrial parks to adopt circulatory economic production pattern. [4]

4. Circulatory Industrial Cluster, the New Industrial Organization Pattern under Low-carbon Economy Background

4.1 Connotation and structure of circulatory industrial cluster

Circulatory industrial cluster refers to the industrial cluster created and constructed pursuant to industrial ecology principles and circulatory economy concept and operated under circulatory economy pattern. It is a spatial aggregate with material, energy and information circulation functions and is composed of a good many of enterprises and relevant organizations linked by industrial chain, ecological chain, value chain as well as generality and complementarity in a specific region. Circulatory industrial cluster organizes production and operating activities pursuant to the principle of resource utilization maximization and environmental pollution minimization, the feature of multi-level circulation and cascade utilization of materials and energies, the platform of resource and information sharing, the means of technical innovation and in the purpose of pursuing high economic efficiency and ecological benefit and develops efficient and ordered self-organized structure as well as cooperative and innovative ecological network on the basis of government support, market development and enterprise innovation.

From the perspective of formation subjects, circulatory industrial cluster is firstly composed of a number of mutualistic enterprise clusters following material circulation relations. These enterprise clusters are in turn aggregated by a number of relevant enterprises, which include both homogeneous competitive enterprises and heterogeneous symbiotic enterprises and establish the complicated competitive and cooperative relations. From the perspective of network chain structure, the industrial chain within circulatory industrial cluster includes both value chain and ecological chain of an industry. The two industrial chains which fail to overlap completely interleave within the cluster and form the complicated self-similar circulatory network structure with multinest and multiple circulations and thus assemble the characteristic of self-similar structure of complex self-organized structure.



(a) Industrial Cluster Structure (b) Circulatory Economy Structure (c) Circulatory Industrial Cluster Structure

Fig.1 Enterprise Relation Structure Profile in Industrial Cluster, Circulatory Economy and Circulatory Industrial Cluster

From the perspective of circulation level, material circulation within circulatory industrial cluster is performed on network loop with multiple levels and multinest and involves microcirculation within enterprises, medium circulation among enterprises in the cluster and greater circulation among all clusters. In addition, all the circulation routes have the characteristic of nested loop network. From the perspective of symbiotic structure, the inside of circulatory industrial cluster is similar to a natural ecological structure owing to the existence of producer enterprise cluster, consumer enterprise cluster and

decomposer enterprise cluster. Closed-loop flowing industrial symbiotic network is formed owing to the longitudinal closure and transverse coupling in terms of material, energy and information flowing among enterprises and clusters. The structure profile of circulatory industrial cluster is shown in Fig.1 (c). [5]

4.2 Benefit analysis of circulatory industrial cluster

Circulatory industrial cluster is the agglomeration of enterprises, their subsidiaries and underlings manufacturing products of the same kind and other enterprises in relation to wastes from production in geographical space. Thus, circulatory industrial cluster, on the one hand, possesses the competitive edge of industrial cluster and on the other, saves resources and energies and protects ecological environment. The main characteristics of its organization pattern include specialized labor division, dealing cost saving, knowledge innovation and overflow, resource saving and recycling of wastes from production. Hence, while combining the advantages of the two organization patterns, industrial cluster and circulatory production, circulatory industrial cluster takes the economic benefit and ecological benefit of enterprises into comprehensive consideration to eliminate wastes from production completely while guaranteeing economic benefit of enterprises and to eventually maximize the economic benefit and ecological benefit of enterprises. Every economic system can create some economic benefits and ecological benefits. Due to the different industrial organization patterns adopted, economic benefit and ecological benefit of the same industry can either be profit or loss. We call the loss negative benefit of an industry and the profit positive benefit of an industry. The benefit of an industry undergoes a dynamic and changing process. There will be losses for any industry as they are newly established and suffering from serious recession, while there will be profits when the industry develops stably and becomes mature. Here, we set up coordinates and divide quadrants with ecological benefit index and economic benefit index respectively as shown in Fig. 2:

(a) Benefit Index Range of Industrial Organization (b) Distribution Areas of Indices with Better Comprehensive Benefit

Fig.2 Benefit Index Range and Area Distribution of Industrial Organization

According to the benefit analysis of the foregoing three patterns, i.e. traditional industrial cluster, circulatory production and circulatory industrial cluster, when an industry develops under the three patterns and when it is under stable state, the benefit index range should be located at area A or B in Fig. 2(a) as traditional industrial cluster creates more economic benefits; the benefit index range should be located at area A or C in Fig. 2(a) as circulatory production creates more ecological benefits; the benefit index range has to be located at area A in Fig.2 (a) as circulatory industrial cluster achieved the combination of economic benefit and ecological benefit and creates more economic benefits and ecological benefits. Circulatory industrial cluster is the advantage assembly of industrial cluster and circulatory production and the area A_{HH} in Fig.2 (b) is the optimum operating state, under which, the economic benefit and ecological benefit of the industry are both at their best.

4.3 Circulatory industrial cluster is the effective approach to the construction of green growth pole in western regions

The traditional development pattern is based on growth pole theory and supported by industrial cluster and promotes the development of surrounding areas by the development of key areas. The basic idea of growth pole theory is that economic growth occurs at some growth points or growth poles in different

intensities rather than occurring in all places and departments. Generally, some rapidly developed leading departments or enterprises with innovation capacity expand (radiate) to adjacent areas via different channels and eventually promote the common economic development of the entire area. Growth pole theory is of great significance to regional economic development. In particular, it plays a pivotal role in the rapid economic growth in underdeveloped areas.

The harmonious development of regional economy and society requires for both rapid economic growth and sustainable resources and environment. Circulatory industrial cluster is a kind of industrial ecological network system, which not only covers relevant enterprises and public institutions, including raw material suppliers forwardly linked, distributors and customers backwardly linked as well as auxiliary product and complementary product manufacturers horizontally linked with value chain and ecological chain of the industry, but also covers relevant enterprises recycling the wastes as well as intermediary service institutions providing professional training, ecological research and cleaner production technology supports. In such an ecological system, enterprises become the nodes of each biological chain (food chain) and coupling relation and symbiosis are developed from resource and by-product linkages among enterprises. All the by-products are maximally digested and absorbed within the system and thus no waste or few wastes will be produced. In this way, not only the resource bottleneck can be broken through, environmental pollution can be reduced, but also low-cost expansion of economy can be achieved. Research shows that circulatory industrial cluster is able to maximize both the economic benefit and ecological benefit of an industry at the same time and thus is the optimal industrial organization pattern promoting the historical breakthrough of the economy and society of underdeveloped areas. It will surely become the “green growth pole” of economic and social development of underdeveloped areas. To develop economy in underdeveloped areas, regional green growth pole shall be cultivated and developed under the support of cities (regions), circulatory industrial clusters and leading industries to effectively promote the leap-frog development as well as sustainable and harmonious development of regional economy.

5. Conclusion

Circulatory industrial cluster pattern, a new industrial organization pattern able to achieve the maximum economic benefit and ecological benefit simultaneously is put forward in this paper. The pattern is available for reference and guidance for the construction of “green growth pole” of industrial development planning and regional economy under low-carbon economy background in the new era. In the meantime, as a brand new industrial organization pattern, the specific construction of circulatory industrial cluster is still explored in practice. Many problems at the micro-level of circulatory industrial cluster in specific regions and industries are still worth further research.

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